

HRA Modeling for Rail Risk Assessments

Presentation to PTC RSAC
Colorado Springs, August 15, 2001

by

Emilie Roth

Roth Cognitive Engineering

John Wreathall & Dennis Bley

The WreathWood Group

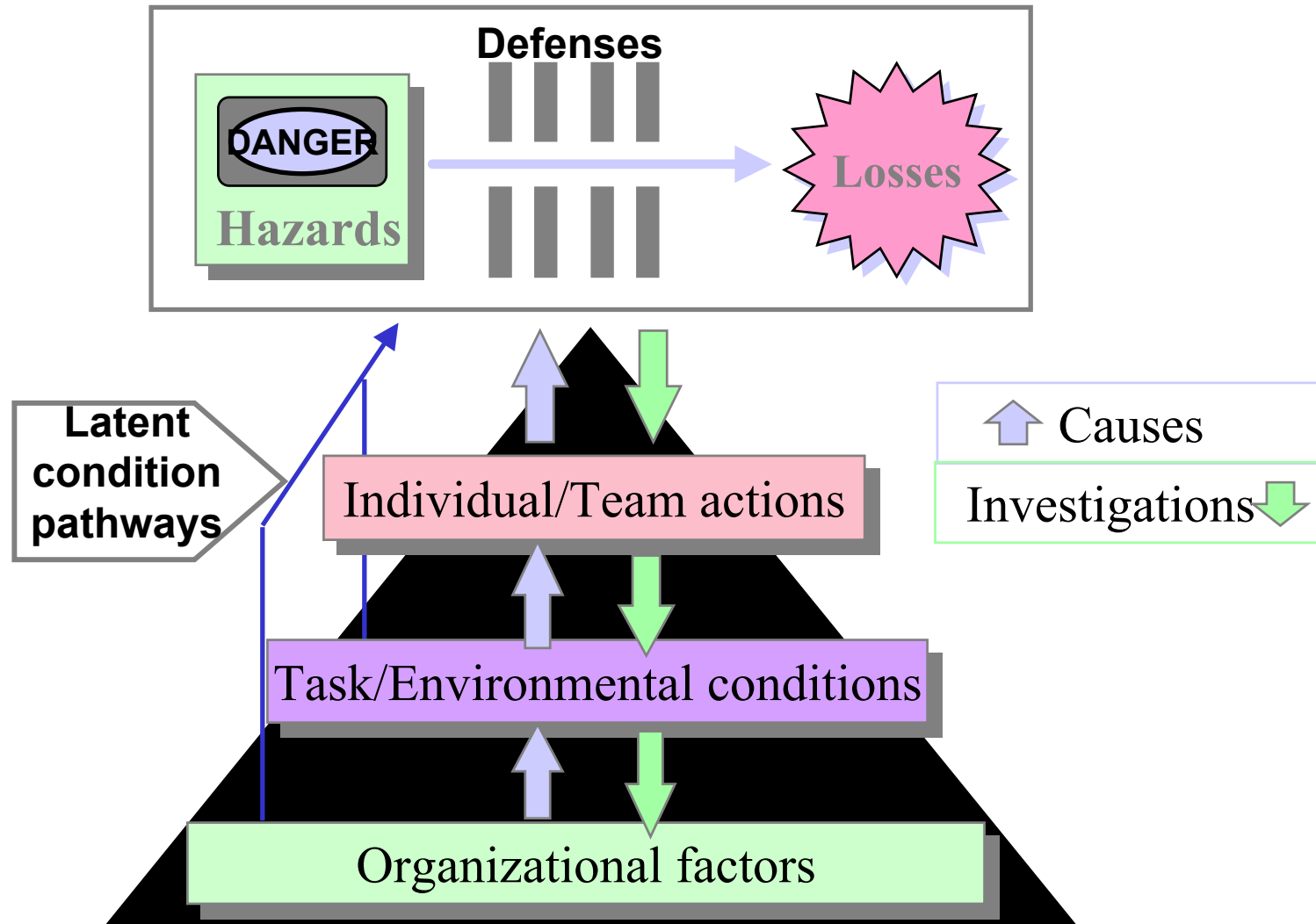
Jordan Multer

Volpe National Transportation Systems Center

Major Goals of HRA Study

- Develop and document HRA tools for use in railroad risk assessment applications
- Demonstrate the HRA tools using the ASCAP analysis of CBTM in dark territory as a case study
- Iterate with RSAC & ASCAP on refining the process and methods, to ensure consistency of analysis

Our View of “Human Error”



(From *Managing the Risks of Organizational Accidents*, Reason, 1997)

Characteristics of a Satisfactory HRA Method

1. It is useable for resolving the issue(s) at hand
2. It is simple, consistent with the needs of (1)
3. It can provide satisfactory explanations for its results
4. Its results and explanations are adequately consistent with historical experience within the context of the issues of (1)
5. It is capable of withstanding scrutiny and review
6. It is capable of being updated or revised with new experience (data or knowledge)

HRA Approach

- Qualitative Evaluation of Human Factors Issues
- Survey of databases for HRA sources
- Trial Quantification Workshop
- Second Quantification Workshop
- Document process & issues in application

Task Status

- Issued ‘Ball Park Human Error Rate Review for ASCAP’, April 2001
- Conducted interviews and observations of CSX Locomotive Engineers and Conductors in Spartanburg, SC on April 18 and 19.
- Conducted interviews and observations of CSX Dispatchers in Jacksonville, FL on June 4 – 6
- Held Trial Human Reliability Quantification Workshop at the FRA headquarters on July 12 – 13 .

Remaining Tasks

- Second Quantification Workshop
 - Complete HRA quantification
 - October 29 & 30 at Spartanburg, SC
- Document process & issue report

Objectives of Qualitative Evaluation

- Identify the major sources of human risk and reliability in the base case
- Identify the likely impact of the new system on human performance

Results feed into the HRA quantification process & provide additional information to support evaluation of proposed system (Product Safety Plan)

Sources of Human Risk & Reliability

- What are the most likely forms of human error in the base case?
- What are the factors that are most likely to contribute to those errors?
- What recovery mechanisms do humans provide that contribute to a robust, high-reliability system?

Impact of New System on Human Performance

- Does the new system prevent and/or catch and recover from the types of human errors that are known to occur in the base system?
- Does the new system change how the human performs?
 - potential for complacency/reliance/distractions
- Does the new system introduce any new sources of risk? Can the human catch and recover from ‘system errors?’

Approach

- Conducted interviews and observations of CSX Locomotive Engineers and Conductors in Spartanburg, SC (April 18 and 19)
- Conducted interviews and observations of CSX Dispatchers in Jacksonville, FL (June 4 – 6)

Results: Likely Human Errors and Their Contributors

- Locomotive Engineers:
 - Failure to reduce speed or stop at end of authority (or work zone) due to attention lapses or failures of memory
 - More likely in cases where:
 - restrictions are temporary (temporary speed zones, work zones)
 - signs are lacking
 - information was communicated verbally (not in train bulletin)

Results: Likely Human Errors and Their Contributors

- Dispatchers:
 - Verbal miscommunication
 - Fail to inform locomotive engineer of temporary speed restriction that came in after train left.
 - Data entry error in Computer Aided Dispatch System (e.g., inadvertently cancel a block)
- Contributors: poor radio reception, high workload, user interface limitations

Sources of Recovery

- Most ‘errors’ are caught and recovered immediately before they have any safety consequences:
 - by individual who made the error
 - by the person they are talking to on the radio
 - by a ‘third party’

Impact of CBTM

- Ability to catch & recover from likely human errors:
 - Unanimous consensus among CSX locomotive engineers, conductors, dispatchers, trainers and managers that CBTM will help catch and recover from human errors of most concern:
 - exceeding speed restrictions (especially temporary speed restrictions)
 - entering work zones
 - exceeding block authorities

Impact of CBTM (Prototype)

Impact on human performance:

- Potential source of distractions
- Complacency and over-reliance on CBTM is not likely to be a serious problem
- Intentional actions to defeat CBTM (e.g. entering incorrect consist information) are not likely
- Likely to impact braking strategy -- there is a learning curve/need for training

Impact of CBTM (Prototype)

- New Sources of Risk:
 - CBTM may cause the train to stop at an inappropriate time or place
- Characteristics of CBTM prototype limit the ability of the human to catch and recover from ‘system errors’:
 - Warning message/Audio alert can be missed
 - The locomotive engineer does not always have enough time to take action to avoid application of penalty brake

Conclusions from Qualitative Analysis

- CBTM is likely to be effective in catching and recovering from human errors
- Refinements to CBTM could enhance the ability of the human to ‘catch and recover’ from potential ‘system errors’
- Benefits of ‘person-in-the-loop’ testing before final implementation

HRA Approach

- Qualitative Evaluation of Human Factors Issues
- Survey of databases for HRA sources
- Trial Quantification Workshop
- Second Quantification Workshop
- Document process & issues in application

Selection of Methods

- Some basic principles for *any* HRA application
 - Real data are better than generic modeling estimates
 - Data rarely match exactly the modeling needs
 - Scenarios
 - Conditions
 - Need to make judgments to fit available data to modeling requirements
 - Uncertainties need to be handled explicitly
 - Can adjustments be made for particular performance shaping factors?
 - Workload, fatigue, time-of-day, weather

Database Survey

- What exists?
 - FRA Data
 - Incident data
 - Operational experience
 - CSX Data
 - Incident data for Augusta – Spartanburg
 - “No-name” disciplinary data for train crews & dispatchers
 - Sample Authority printouts
 - CANAC Data
 - Incident data
- Most have relevance
- All have weaknesses

Relationship to ASCAP Model

- ASCAP models human actions at 3 levels
 - Recognition
 - Coverage
 - Response
- HRA data can generate data for each level or for a composite failure rate
 - “Composite” matches typical sources of data
 - “3 levels” can be estimated on a relative basis

Example Analysis

- Train exceeds limit of block authority
 - Two basic ways that this can happen due to human actions
 - Train crew fails to stop train at boundary
 - Train crew does not receive correct authority from dispatcher
 - Do not imply blame, just what can happen
 - We will use first in example

Event Data Analysis

- Employee disciplinary actions for track segment (TS) violations
 - All of CSX
 - Is CBTM trial territory equivalent to rest of CSX?
 - What are differences? What impact on TS violation rate?
 - Fraction of under-reporting?
 - Reporting process?
 - How much of a violation of authority is a “real” violation?
 - 40% of “violations” are less than 100 feet (CANAC)
 - Are these in the database?
 - Should we count them?

Engineer Disciplinary Actions for Track Segment (TS) Violations (CSX-wide)

| Year | No. |
|------|-----|
| 1992 | 14 |
| 1993 | 10 |
| 1994 | 9 |
| 1995 | 17 |
| 1996 | 12 |
| 1997 | 17 |
| 1998 | 20 |
| 1999 | 20 |
| 2000 | 34 |

Operating Experience Data

- FRA database for CSX shows yard & total train-mile experience
- What fraction of total non-yard operating experience is “dark territory”?
 - 50%? 60%?
 - Interviewees said that Spartanburg-Augusta was “typical” of CSX dark territory
 - Is this agreed? Better? Worse? By how much?
- Do the TS data include yard incidents?
 - What fraction are in yards?
- Is OK assign ranges to judgments

CSX Operating Experience

| Year | Dark Territory train-miles | Dark + yard train-miles |
|------|----------------------------|-------------------------|
| 1992 | 27,973,000 | 39,362,000 |
| 1993 | 29,413,500 | 40,781,500 |
| 1994 | 34,241,000 | 46,304,000 |
| 1995 | 35,318,500 | 47,913,500 |
| 1996 | 35,309,500 | 48,176,500 |
| 1997 | 35,091,500 | 48,611,500 |
| 1998 | 34,957,500 | 48,462,500 |
| 1999 | 44,519,500 | 60,728,500 |
| 2000 | 48,208,000 | 66,085,000 |

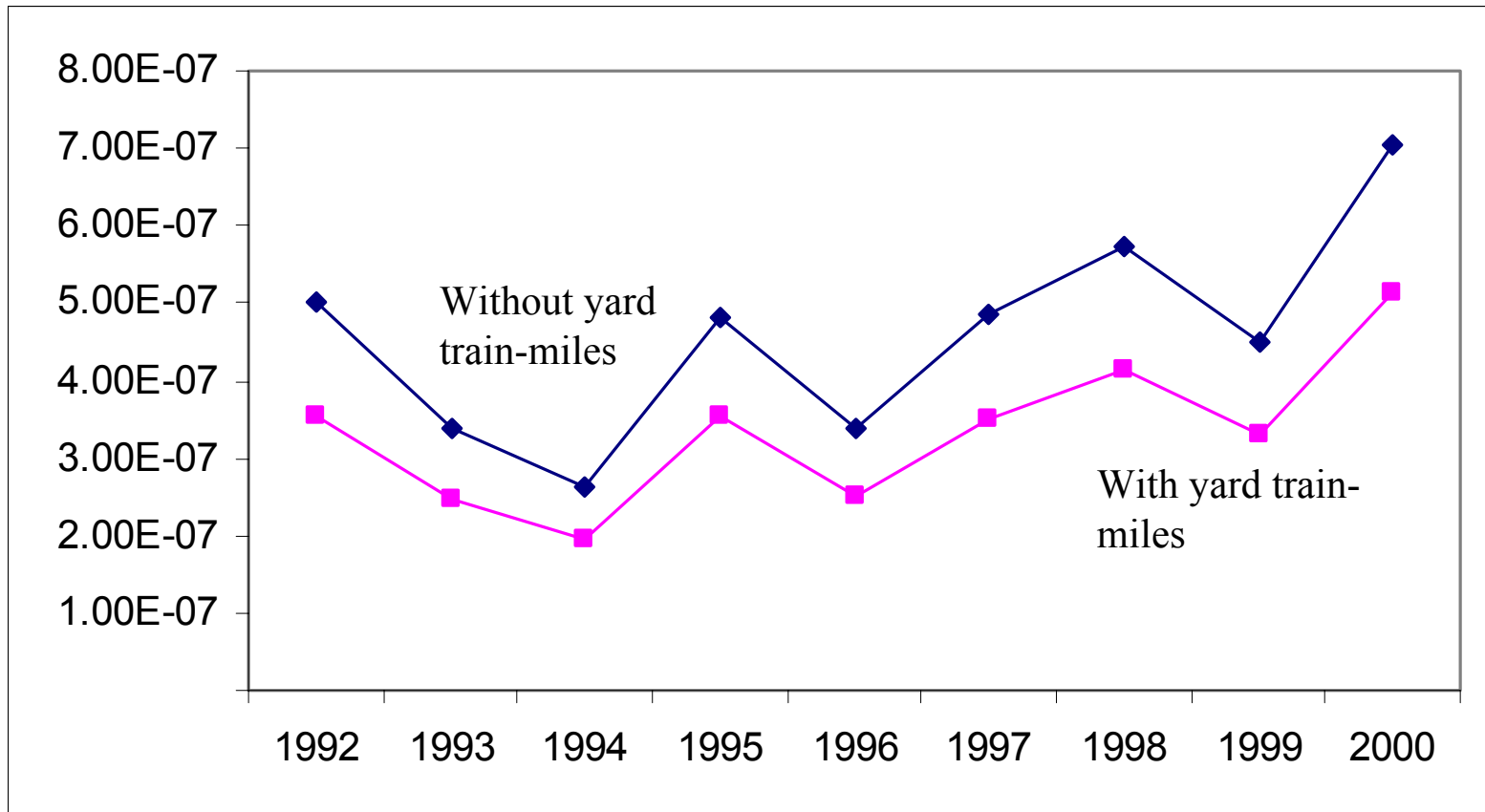
Dark territory is assumed 50% of all non-yard territory for CSX for this example

Implied Event Rate

| Year | Rate/dark territory t-m | Rate/dark+yard t-m |
|------|-------------------------|--------------------|
| 1992 | 5.00E-07 | 3.56E-07 |
| 1993 | 3.40E-07 | 2.45E-07 |
| 1994 | 2.63E-07 | 1.94E-07 |
| 1995 | 4.81E-07 | 3.55E-07 |
| 1996 | 3.40E-07 | 2.49E-07 |
| 1997 | 4.84E-07 | 3.50E-07 |
| 1998 | 5.72E-07 | 4.13E-07 |
| 1999 | 4.49E-07 | 3.29E-07 |
| 2000 | 7.05E-07 | 5.14E-07 |
| Avg | 4.60E-07 | 3.34E-07 |

1.00E-6 is "1 in 1 million"
1.00E-7 is "1 in 10 million"

Graphically...



1.00×10^{-6} is "1 in 1 million train miles"

1.00×10^{-7} is "1 in 10 million train miles"

Outcomes from Data

- Traffic along Augusta-Spartanburg territory
 - Estimated to be 1 million train-miles/year (ASCAP estimate)
- Using all TS events in CSX database & non-yard dark operating experience, the frequency of violating authority is:
 - 4.6×10^{-7} /year x 1 million train-miles
 - 0.46/year, or once every 2.2 years
- Is this too low?
 - Under-detecting and reporting events?
 - What should be the relative fraction?

ASCAP-related Analysis

- 1 million train-miles is for 1 year (ASCAP)
- Route is 120 miles
 - Average number of trains = 8,333 /year
- Each passes through 20 blocks
 - 166,700 block boundaries passed/year
 - Failure rate = $0.46/166,700$
 $= 2.76 \times 10^{-6}$ per block boundary (total)
 - Assumes each boundary is an opportunity to exceed
(Need to match up to ASCAP assumptions)

Uncertainty Analysis

- Instead of “single point” values taken from databases, data represented by distributions based on subject matter experts’ evidence
- Impacts “mean” versus “best estimate” probs
 - Example: Numbers of events
 - Extent of under-reporting?
 - Any over-reporting?
 - Fraction of CSX-wide events taking place in dark territory?
 - Similarity of Augusta-Spartanburg to other dark territory?
 - Other data sources?

Trial Quantification Workshop

- Performed to evaluate different approaches to HRA estimation process
- Included FRA, CSX, HRA Team
 - To identify what data were available
- Conclusions
 - Practical approach was possible by combining data and judgments
 - 4 or 5 actions modeled
 - Whose judgments & which data are important
 - Need to expand sources of expertise

Second Quantification Workshop

- Purpose: To provide demonstration quantification for CBTM Study
- Participants will include labor groups, CSX, FRA as subject matter experts & stakeholders
 - To evaluate and modify database sources based on knowledge & experience
- Dates & location
 - October 29, 30
 - Spartanburg, SC

Roadmap for Completion of Project

- Second workshop will develop HRA probabilities for CBTM case
- Document HF & HRA processes for future applications:
 - How to proceed
 - Interfaces with ASCAP or other risk assessment models
 - Quantification process
 - Databases
 - Modeling
 - Workshops
 - Documentation of results for safety case decisionmaker(s)

End